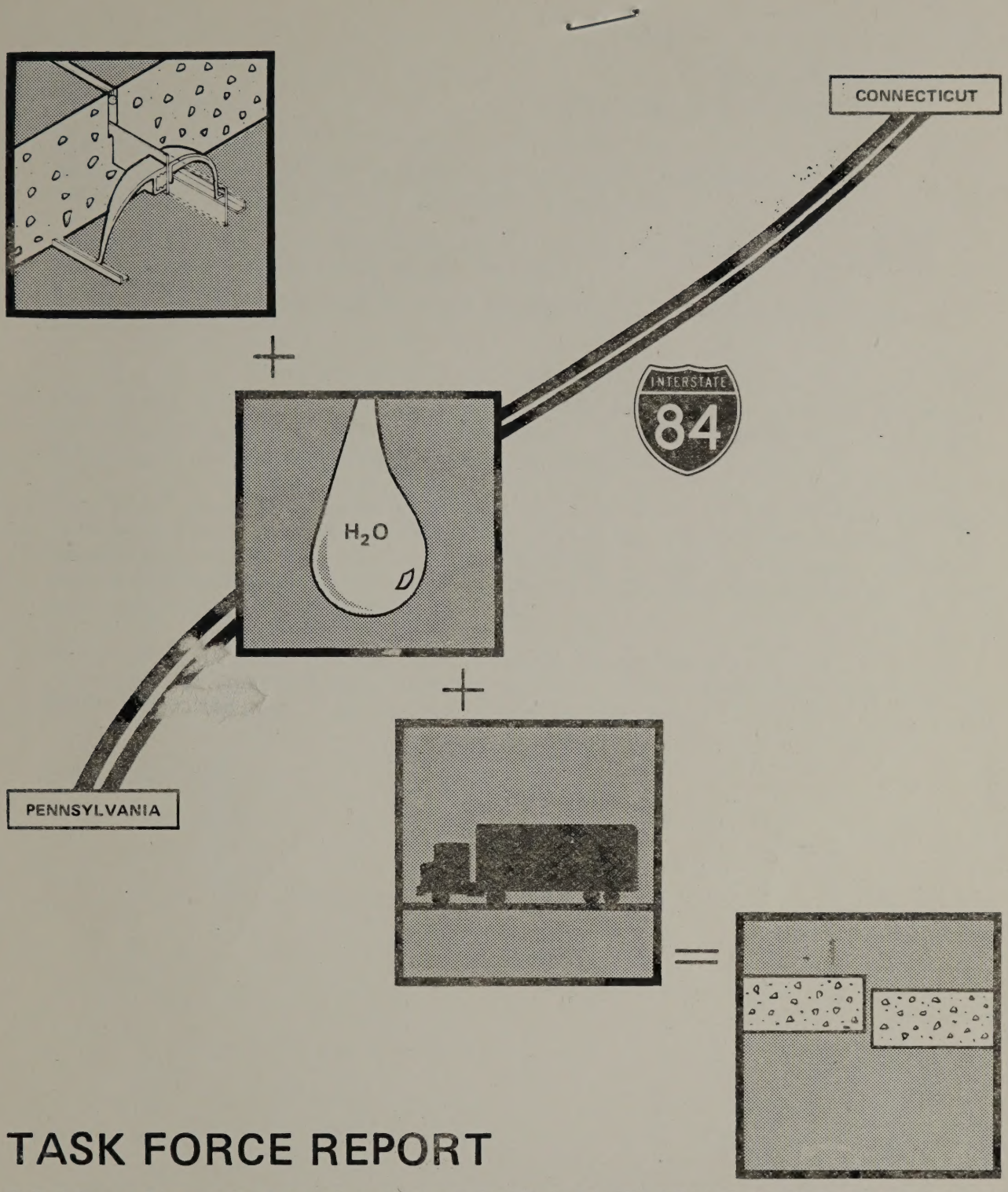

TASK FORCE REPORT

PORTLAND CEMENT CONCRETE PAVEMENT PERFORMANCE

INTERSTATE 84

PENNSYLVANIA STATE LINE TO CONNECTICUT STATE LINE

MARCH 1978

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
WILLIAM C. HENNESSY, Commissioner

MEMORANDUM

DEPARTMENT OF TRANSPORTATION

DATE March 14, 1978

SUBJECT TASK FORCE REPORT
PORTLAND CEMENT CONCRETE PAVEMENT PERFORMANCE - INTERSTATE 84
PENNSYLVANIA STATE LINE TO CONNECTICUT STATE LINE

FROM Lyndon H. Moore, Soil Mechanics Bureau, Room 102, Bldg. 7
By: Wesley P. Moody, Task Force Chairman

TO Wm. P. Hofmann, Technical Services Subdivision, Room 210, Bldg. 7A

The performance of the portland cement concrete pavement on I-84 has been investigated as you requested on February 25, 1977. The major problem is faulting of transverse joints in the travel lane.

The "Acme" type load transfer device and free water in the pavement section have been identified as two important causes of the faulting problem. Rehabilitation techniques to restore rideability and to alleviate deterioration are recommended in the report as is a strategy for assigning priorities for the rehabilitation work.

The recommendations in this report should be applicable to many miles of distressed portland cement concrete pavement in New York State that was built using the same type of load transfer device.

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PORTLAND CEMENT CONCRETE
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INTERSTATE 84

Pennsylvania State Line

to

Connecticut State Line

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March 1978

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I. INTRODUCTION

Interstate 84 in New York State is 72 miles long. It forms a link in the route that starts at Interstate 81 near Scranton, Pennsylvania on the west and presently extends to the vicinity of Hartford, Connecticut where it connects to other Interstate routes which radiate throughout New England. This route is an important connector for traffic flowing between New England and the South. It is the only Interstate route in the area that bypasses the New York City area and hence is a heavily used truck route.

The New York State portion of Interstate 84 was constructed under 16 contracts that were let between 1962 and 1968. The pavement is 9 inch thick portland cement concrete with transverse joints spaced at 60 foot - 10 inch intervals. Each joint has a two component load transfer device of the "Acme" type design.

In 1976, Regional Maintenance personnel observed a significant faulting problem at transverse joints at various locations. The magnitude of the problem and the inherent implications for future rehabilitation work led to the establishment of a joint Regional - Main Office Technical Services group to investigate the causes of the transverse joint faulting problem and to recommend rehabilitation techniques.

II. INVESTIGATIONS

Preliminary Work

The first activity was to compile the construction history for each of the 16 contracts. Data gathered included typical sections, applicable standard sheets, the subbase items utilized and material sources. A pavement core was obtained at a transverse joint on a majority of the construction contracts to verify the type of load transfer device actually in place and its condition. Prior to the first field inspection, the available photolog films were viewed.

A general field inspection of the entire length of roadway, both eastbound and westbound, was made with stops at typical problem areas to identify the distress type, severity and approximate frequency of occurrence. The predominate pavement distress was observed to be faulting of transverse joints in the travel lane. See Photograph 1.

Based on both the office and field information gathered, it was decided to remove sections of pavement and transverse joint assembly at six locations. At each location, subbase and subgrade material were first field tested and then sampled for laboratory testing. The test locations were chosen based on year of letting and the faulted condition of the joint. A good (level) and poor (faulted) joint were selected on the same contract for the letting years of 1962, 1964, and 1966. The locations follow:

CONTRACT NO.	REFERENCE MARKER	PROFILE	JOINT CONDITION
FISH 62-1	841-82021023 E.B.	Fill	Poor
FISH 62-1	841-82021017 W.B.	Fill	Good
FISH 64-9	841-83011016 E.B.	Cut	Poor
FISH 64-9	841-83011044 E.B.	Rock Cut	Good
FISH 66-8	841-83011163 E.B.	Fill	Poor
FISH 66-8	841-83011175 W.B.	Cut	Good

Pavement Condition Survey

An integral part of this investigation was the determination of pavement condition in quantitative terms, therefore, several indices of deterioration were measured or tabulated. Since New York's portion of I-84 is 72 miles long and was constructed under 16 different contracts, a complete survey was not feasible and therefore only portions of eight contracts were selected for intensive study. The initial choice included two sections containing serious deterioration, then six others to represent the 1962-68 range of contract letting dates. The actual portions measured were designated in the office from plans to remove the bias inherent in a field selection. All faulting data was collected in the travel lane because the field inspection showed little or no faulting in the passing lane.

Faulting was measured to the nearest 1/16 inch and the condition of the joint seal was recorded for both lanes at over 1400 joints in the eight contracts. Differential vertical movements of adjacent slabs across a transverse joint were measured using a truck with a 22,400 lb. axle load, the legal maximum in New York State. These measurements were made on six joints to either side of each of four removed joint assemblies.

Finally, the location and length of all pavement cracking was recorded for the faulting measurement sections.

Test Sites

Joint assemblies were removed from the right edge of the travel lane adjacent to the shoulder at six locations. The pavement was sawed in a 2 foot by 3 foot rectangle with the joint assembly in the center of the long dimension. To insure that the assembly would remain intact during slab removal, the two sides were fastened together securely by steel channels anchored to the concrete by expansion-bolts prior to sawing.

After slab removal, a visual inspection of the test pit was made. In all instances, a ridge of soil material was found to exist directly below the joint assembly. A profile of the top of subbase material was made across the test hole in the direction of travel.

It is necessary to define a "leave" and "approach" slab as used in this report. Consider the transverse joint as a reference point. A wheel load moving in the forward direction of travel will first traverse the "approach" slab, pass over the joint and then traverse the "leave" slab.

Samples of material were obtained from the ridge of soil material under the joint, the top surface of the upper subbase course for both leave and approach sides of the joint, the upper subbase course on both the leave and approach sides, the lower subbase course on both the leave and approach sides, and the subgrade.

In-place field density measurements were made in the upper and lower subbase courses and in the subgrade. These tests were performed using the Troxler Model No. 3401 nuclear density device. Some in-place density tests were made utilizing the standard Proctor sand cone method where conditions permitted. All values were recorded as total wet densities.

The removed concrete and joint assemblies were transported to Albany for further laboratory investigation.

Traffic Studies and Axle Loading

Traffic count and axle load data were compiled at several locations along I-84. Region 8 personnel supplied the vehicle counts and classifications at six locations while Task Force personnel, using an axle-weight analyzer, compiled axle load data at six sites. Measurements were taken at locations where significant traffic volume changes were expected.

III. RESULTS AND DISCUSSION

Pavement Condition Survey

Faulting of transverse joints is one of the most common types of concrete pavement distress as well as a principal cause of serviceability loss. The causes include settlement or erosion of material under the slabs and inadequate load transfer across the joint. Once faulting commences these factors become an effect as well as cause, contributing to its progression and each is worsened by the differential vertical movement induced by heavy wheel loads. Thus, once started, faulting will continue to increase unless corrective measures are taken. After faulting has progressed to a point, transverse cracks appear in the pavement slab near the joint. In time, these cracks may also be subject to faulting.

Faulting was measured on I-84 at over 1400 transverse joints using an Engineering Research & Development Bureau device fabricated for this purpose. All measurements were made in the travel lane, six inches from the outside (shoulder) edge. The measurements are given in 1/16 inch units and positive faulting is when the leave slab is down. Of the pavement studied, there were very few joints with negative faulting.

Table 1 presents a summary of all faulting measurements. Previous work has shown that faulting becomes noticeable to the motorist when it averages 2/16 inches and objectionable at 3/16 inches to 4/16 inches. Thus, the figures in Table 1 show that most of the measured sections have noticeable faulting and it is objectionable on significant portions as evidenced by both the averages and the percentages of individual readings greater than 3/16 inches. Most of the average readings are over 2/16 inches, putting them in the "noticeable" range, and some are greater than 3/16 inches, becoming "objectionable."

Because the average faulting figures indicate an increase with age, a regression analysis was run using the average figures for each contract (east and westbound together). The age was determined by assuming that each section was opened two years after the letting date. Thus, for a 1962 contract, the age used is 1977 -(1962 + 2) = 13 years.

The results are shown in Figure 1. A significant correlation was obtained, indicating that the progression of faulting on this pavement can be predicted reasonably well and the newer contracts could reach the distress level of the older ones at similar ages. In other words, faulting will continue to increase unless corrective measures are taken.

Table 1 also contains the results of visually evaluating joint seal conditions. Only a "good" or "not good" rating was applied, good indicating the sealer was in place with no protrusion above pavement level. However, experience indicates that even under these circumstances, most of the seals have probably failed, i.e., they are not keeping water and de-icing chemicals out.

TABLE 1. SUMMARY OF TRANSVERSE JOINT FAULTING MEASUREMENTS AND SEALER CONDITION

Contract No.		ALL MEASURED JOINTS			JOINTS WITH POOR SEALS		
		Faulting (1/16 in. Units)		% of n >3/16 in.	Faulting (1/16 in. Units)		% of n >3/16 in.
		n	$\bar{x}$		n	$\bar{x}$	
62-1	WB	77	3.1	40	28	3.5	36
	EB	43	10.3	98	43	10.3	100
62-6	EB	17	6.2	88	0	-	-
64-9	WB	329	3.2	40	47	4.0	14
	EB	330	5.3	72	24	4.8	7
66-3	WB	53	1.8	11	0	-	-
	EB	53	2.6	23	0	-	-
66-8	WB	9	3.8	56	4	3.3	44
67-14	WB	44	3.2	39	20	3.6	45
	EB	45	3.2	33	8	1.5	18
68-1	WB	70	2.4	23	0	-	-
	EB	71	2.6	21	0	-	-
68-13	WB	49	2.8	36	0	-	-
	EB	50	1.1	0	0	-	-

n = Total Number Of Items In The Sample

$\bar{x}$ = Arithmetic Mean Of The Sample

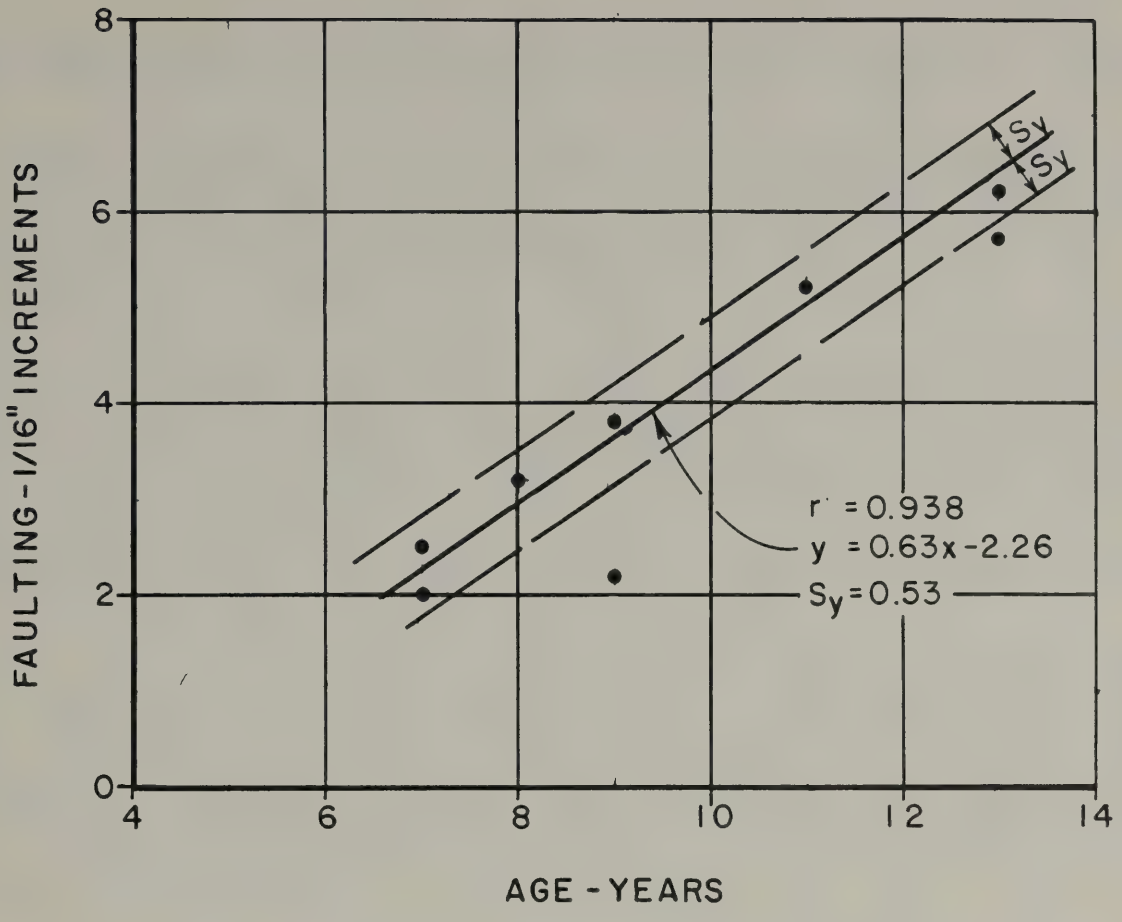


FIGURE 1
REGRESSION ANALYSIS OF
FAULTING VS AGE

r = Correlation Coefficient
y = Dependent Variable
S_y = Standard Error of Estimate

This condition explains why there are no apparent increases in the faulting magnitudes at joints where the sealer was considered "no good."

Faulting was analyzed in relation to grade and embankment cross-section. The latter was divided into cut, fill, and sidehill with pavement either on the cut or fill side. There was a slight trend towards greater faulting on fill sections, but the number of joints measured on the three other types of section was not sufficient on enough contracts to be meaningful.

There was an adequate distribution of grades on the six contracts listed in Table 2. Four sites, each including all four travel lanes, were on long grades. These are indicated by EB or WB following the faulting averages. In general, faulting is greatest on positive grades (all positive grade readings are in the direction of travel). This is to be expected because of the slower speed of heavy vehicles and more force on the joint area where a vertical force is actually directed slightly towards the joint as the tires cross it. Moreover, the natural flow of water on positive grades helps transport soil particles from beneath the leave slab to the approach slab.

Table 3 summarizes the results of measuring the differential vertical movement across transverse joints at four locations. Using a 22,400 pound single-axle load, these movements were measured to the nearest 0.001 inch on sections with varying degrees of faulting. None of these movements were large. Thus, at the time of measurement the slabs were relatively stable. Weather records for the area show that no appreciable rain fell for nearly two weeks prior to these measurements which meant the pavement section had received little infiltration of surface water.

Pavement cracking was measured and recorded for slabs in the faulted sections surveyed. Table 4 contains a summary showing the number of slabs that had transverse, longitudinal, and corner cracking. The most prevalent was transverse cracking, appearing in close to 30 percent of the slabs on two contracts. None of the cracking, however, was present in sufficient quantities to be considered an unusual problem.

Traffic Analysis

The Engineering Research & Development Bureau's Viatec Axle-Weight Analyzer was used to measure traffic loading at six locations. This device counts and categorizes axles in 4,000 lb. increments, providing data appropriate for conversion to 18 kip equivalent single axle loads (ESAL).

Counts were taken for 18 to 22 hours at each location and converted to 24 hour figures, then to 18K - ESAL's. Table 5 summarizes these counts and lists the faulting averages. The contracts are listed as they occur along I-84 from west to east. All contracts where either axles or faulting were measured are listed.

There is a trend between faulting and total axle loads, but it appears less significant than the trend with age. For example, Contract FISH 68-13 has been subjected to 4.1 million 18K - ESAL's and FISH 62-1 to 5.2 million, yet

TABLE 2. EFFECT OF GRADE ON FAULTING

Contract No.	Positive Grade		Negative or Flat	
	n	$\bar{x}$(1/16 in. Units)	n	$\bar{x}$(1/16 in. Units)
62-1	43	10.3 (EB)	77	3.1 (WB)
64-9	341	5.3	318	2.9
66-3	43	1.7 (WB)	53	2.6 (EB)
67-14	44	3.1 (WB)	45	3.2 (EB)
68-1	63	3.0	78	2.1
68-13	44	2.7 (WB)	50	1.1 (EB)

TABLE 3. DIFFERENTIAL VERTICAL MOVEMENT (D.V.M.) ACROSS TRANSVERSE JOINTS

Site	Contract No.	D.V.M. (0.001 in.)	Faulting (1/16 in. Units)
1	62-1	2.5	10.5
2	64-9	0.3	1.7
3	64-9	0.3	6.6
4	66-8	12.1	3.5

$\bar{x}$ = Arithmetic Mean Of The Sample

n = Total Number Of Items In The Sample

TABLE 4. SUMMARY OF CRACKING

Contract No.	No. of Observed Slabs	No. of Slabs With Cracking			
		Transverse	%	Longitudinal	Corner
62-1	120	29	24	0	10
62-6	17	5	29	0	2
64-9	659	49	7	9	25
66-3	106	30	28	1	0
66-8	9	1	11	0	0
67-14	89	11	12	3	4
68-1	141	17	12	0	4
68-13	99	25	25	2	1

TABLE 5. COMPARISON OF AXLE LOADS AND FAULTING

Contract No.	18K - ESAL's		Faulting (1/16 in. Units)
	Daily	Total (Million)	
Penn. State Line			
64-9	--	--	4.2
67-14	--	--	3.2
66-8	1520	5.0	3.8
67-6	1725	5.0	--
68-13	1600	4.1	2.0
62-6	1640	7.8	6.2
62-1	1100	5.2	5.7
62-7	1790	8.5	--
66-3	--	--	2.2
68-1	--	--	2.5
Conn. State Line			

the faulting for the latter is almost three times as great. The classification counts made by Region 8 personnel were included in the analysis, verifying the axle counts.

This data shows heavy traffic will initiate and increase faulting but small changes in application rate from one section to another will not necessarily be reflected in faulting magnitude. What becomes important is the number of wet periods the road is subjected to over a length of time. These periods obviously increase with age and it is these cycles that are important.

In other words, while there appears to be a significant range of axle-loading rates along the length of I-84, it is all sufficiently heavy to increase faulting at a relatively uniform rate with time despite some variations in the actual loading magnitude.

All measured traffic data is included in Table 6.

TABLE 6. TRAFFIC DATA FOR INTERSTATE 84

Contract Number	Years In Service	Daily Traffic	% Trucks	Equivalent Axle Loads, 18K x 10^6	Daily Axle Count*	Viatec Axles**
64-9	11	7,910	24.9	6.7	20,732	--
66-8	9	--	--	5.0	--	18,100
67-6	8	--	--	5.0	--	17,616
68-13	7	8,560	32.5	4.1	18,346	15,930
62-6	13	12,790	21.5	7.8	22,548	22,595
62-1	13	--	--	5.2	--	13,671
62-17	13	12,800	20.5	8.5	20,595	20,313
66-4	9	14,295	28.2	6.5	27,824	--
64-6	11	16,800	28.8	9.9	28,113	23,898

* Furnished by Regional forces.

** As counted by Engineering Research Axle-Weight Analyzer.

Analysis of Pavement

Although much of I-84 exhibits some degree of distress at the transverse joints, the slabs themselves were observed to be relatively free of surface deterioration in the form of spalls and cracks. The transverse cracking that did occur appears to be stress related rather than associated with construction. To check this contention, a pavement core was taken through a

transverse crack in the eastbound lane near the Mattawan Hospital. The crack was approximately 15 - 20 feet ahead of the transverse joint in the leaving slab of the travel lane. The core showed that the crack extended through the entire depth of the pavement and predominantly through the aggregate particles. This indicates that the crack was formed well after the concrete was placed and was probably due to friction between the slab and the subgrade. In addition, the crack is considerably wider at the surface than at the bottom of the slab indicating that a hinge has developed around which either or both of the slab sections may still be rotating.

The minor amount of surface scaling indicates that the concrete contains a sufficient amount of entrained air to resist the freeze-thaw cycling and de-icing chemicals and that it should continue to perform well in the future.

An analysis of the skid testing conducted during 1976 shows that the skid numbers are generally in the 30's at a test speed of approximately 55 mph. This would indicate that, although some minor areas of I-84 have skid numbers below a generally accepted minimum value, skid resistance is not a significant problem at this time.

An inspection of the pavement during slab removal showed that, in general, the concrete was placed and vibrated to produce a homogeneous and well-consolidated pavement slab with one major exception: a definite void exists at the subbase surface beneath the centerplate of the transverse joint support assembly. The void most likely extends the entire width of both lanes and is probably due to the difficulty of consolidating the concrete around and under the centerplate used in the "Acme" type system. This type of void probably occurs to some degree in all similar installations but should not seriously affect the functioning of the joint.

It was also noted that some minor cracking has occurred on the bottom corner of the approach slab. This is probably due to the pressure applied by the movement of the leave slab as it moves downward. However, the condition does not appear to be serious and again should not seriously affect the functioning of the joint.

When all six pavement samples had been extracted, they were delivered by Region personnel to the Main Office laboratories for closer visual examination. Once the restraining steel channels were removed, the two segments of the sample were separated easily by crowbars to expose the vertical faces of the transverse joint. The neoprene preformed joint sealers were compressed and had lost much of their ability to rebound to the original shape.

The centerplate and other exposed parts of the joint assembly showed corrosion to some degree. The three samples from the areas which were classified as "poor" showed the top plate of the female end had been worn away due to a combination of corrosion and abrasion which allowed the male end to move in a vertical direction beyond the original dimension of the assembly. It was observed that the movement of the male part resulted in a wearing away of the concrete immediately above the original female insert which created a vertical slot in which the male end can move. It is most likely that the existing condition resulted from a cycle of faulting leading to elongation of the

vertical slot which led to more faulting. In any event, the joints represented by these samples have lost the ability to transfer loads across the transverse joint. See photographs in Appendix.

The three samples from the areas classified as "good" showed the joint assemblies, except for minor corrosion, are much the same as originally installed. The top of the female end is still intact in each case. See Figure 2. The

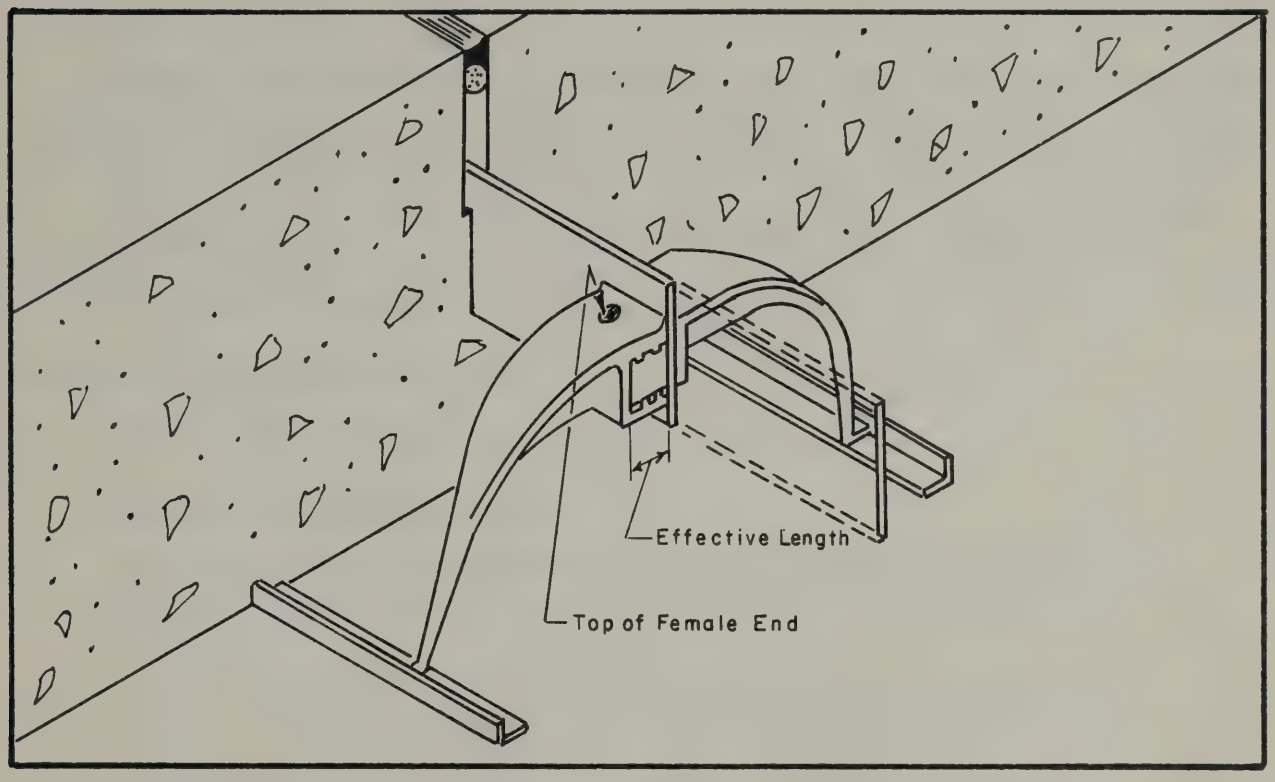


FIGURE 2. LOAD TRANSFER DEVICE

joints represented by these samples are still functioning as load transfer devices and may continue to do so indefinitely barring any significant change in conditions. See photographs in Appendix.

The joints were examined to determine whether the positioning of the joint assembly was a factor in the faulting. The Standard Sheet for the "Acme" type joint assemblies required that the baskets be so placed that the female end would be pushed toward the male end as the paving advanced. Therefore, the position of the male and female ends in relation to the transverse joint is entirely dependent upon the direction of paving and may not coincide with the direction of traffic flow.

All of the three samples classified as "poor" had the male end embedded in the approach slab indicating that the direction of paving was opposite to the direction of traffic flow.

Of the three samples classified as "good," two had the female end embedded in the approach slab indicating that the direction of traffic flow coincides with the direction of paving. Although the remaining sample had the same arrangement as the three classified as "poor," it may be that one or more additional factors necessary to produce faulting are not present in this particular situation.

The pavement cores obtained by the Region to verify the load transfer device type and condition were also examined. Although the male - female location cannot be determined from the cores, the results are similar to the pavement sections described above. In general, the preformed joint filler has lost its ability to effectively seal against the intrusion of compressible material. Where the joint is still functioning adequately, faulting is at a minimum. Conversely, where the load transfer device has deteriorated through corrosion and abrasion the faulting is much greater.

Analysis of Supporting Courses

See Appendix for Field and Laboratory Test Results.

Upper Course Subbase Items

The specification requirements for upper course include limits for gradation, plasticity index, and magnesium sulfate soundness loss as follows:

ITEM	MAXIMUM PLASTICITY INDEX	MAXIMUM MAGNESIUM SULFATE SOUNDNESS LOSS (%)
4	5	20
39AP	3	20

	GRADATION - % PASSING BY WEIGHT				
ITEM	4 in.	2-1/2 in.	2 in.	1/4 in.	#200
4			100	30-65	0-10
39AP		100		30-65	0-10

There is no compaction standard specified, as this is covered by a procedure specification.

Gradation testing was performed on twelve samples and the results indicated substantial conformance with the specification requirements. It was found, however, that the material was on the fine end of the gradation limits, particularly the 1/4 inch and No. 200 mesh sieve.

All samples had a plasticity index of zero while the magnesium sulfate soundness losses were all below the specification limit.

In-place density tests indicated results which are considered acceptable.

Lower Course Subbase Items

Similar to upper course the lower course specification has limits for gradation, plasticity index and magnesium sulfate soundness loss as follows:

ITEM	MAXIMUM PLASTICITY INDEX	MAXIMUM MAGNESIUM SULFATE SOUNDNESS LOSS
3	5	30

ITEM	GRADATION - % PASSING BY WEIGHT			
	4 in.	1/4 in.	#40	#200
3	100	30-100	0-70	0-10

Gradation testing was performed on seven samples, and again general conformance to the specification was found to exist.

The magnesium sulfate soundness tests resulted in values below the required limit, while the plasticity index values in all instances were zero.

The results of the in-place density testing were within an acceptable range.

Subgrade

In all areas, the subgrade material was found to be suitable. The results of compaction testing indicated substantial conformance with the 95 percent and 100 percent of Proctor maximum density specification requirements.

Water

At the time of investigation there was only one test pit location where the subbase and subgrade soils were wet. This was at Reference Marker 841-82021017 W.B. At all other locations, the subbase and subgrade contained a much lesser amount of water and were described as moist. In fact, it was necessary to utilize a pick and shovel to obtain samples.

No direct observation of free water in the pavement section was made at the time of investigation. Task force members have observed pumping of joints at some locations at other times. Evidence of the presence of free water in the pavement section was observed. Free water is defined as water that is not located within the soil structure. The indications were "blowholes" in the shoulder at the pavement-shoulder joint, the existence of the ridge of soil particles beneath the joint, and the accumulation of fine soil on the surface of the upper course subbase. This evidence combined with past observations of water movement in pavement sections substantiates the contention that free water, when present, flows along the interface between the upper course subbase and the bottom of the concrete slab and not primarily within the subbase soil structure.

The presence of free water when heavy traffic loads are applied result in pumping of the transverse and pavement-shoulder joints causing the loss of soil material and the subsequent development of voids. These voids result in pavement faulting and "blowholes" in the shoulder. The "blowholes" start as elongated depressions a foot or two beyond the transverse joint in the direction of travel. See Photograph 2. When free water is absent, low differential vertical movements occur when a legal axle load passes across the joint.

Ridge Material

The results of gradation testing on the material from the ridge found directly under the joint showed it to have a top size of two inches and up to twenty percent passing the No. 200 mesh sieve. Included in the ridge material were pieces of concrete which had spalled from beneath the joint assembly. The height of the ridge ranged from 0.6 inches to 1.8 inches. See Photograph 3.

IV. SUMMARY AND CONCLUSIONS

In general, the pavement slabs are in good condition. Faulting of the joints is the major pavement problem on the 72 miles of Interstate 84. All the conditions necessary to allow pumping to start are present, namely, free water, small sized soil particles and heavy truck axle loads. In addition, the transverse load transfer device as designed has a sufficiently large tolerance to allow a small vertical movement to occur. Pumping occurs at the transverse joints and at the joint between the pavement and outside shoulder. After the pumping progresses to a sufficient degree, joint faulting develops and progressive deterioration continues unless corrective action is taken.

Field observations and measurements support the following conclusions:

- The design of the transverse load transfer device is an important cause of the distress.

- Free water in the pavement section is an important agent in transverse joint faulting.

- Joint faulting in the travel lane is progressing at a predictable rate with time.

- Joint faulting is more severe on positive grades.

- The poor condition of the joint seals allows the entrance of large quantities of surface water into the pavement section.

- There is a heavy traffic loading along most of Interstate 84 and small differences in its volume are not necessarily reflected in distress levels.

- The amount of slab cracking is not excessive for this pavement's age or traffic volume and is not a very serious problem at this time.

Improvements have been made to the standards for the construction of portland cement concrete pavements since the construction of Interstate 84. The most notable change is the requirement to use dowel type load transfer devices of various designs. The "Acme" type load transfer device is no longer used. Improved joint sealing compounds have become commercially available and are now being used.

The present standard use of non-reinforced portland cement concrete pavement with 20 foot joint spacing reduces the amount of movement at the joint and therefore the joint sealers should perform better.

V. REHABILITATION TECHNIQUES

The measures necessary to correct the existing problems on I-84 can be grouped into two major categories. The slab elevation differentials (step-offs) must be eliminated to restore the pavement to an acceptable degree of rideability to the traveling public; the conditions which have led to the current joint faulting must be corrected to prevent or at least minimize further faulting.

Following are listed some alternate methods and procedures to accomplish these objectives:

Restoration of Rideability

Overlay Pavement

This method would normally involve the placement of 1 inch of high friction aggregate top course (Type 7F) over 1-1/2 inches of a dense graded binder course (Type 3) with Truing and Leveling as required. This would have the advantage of producing a like-new riding surface with an increase in skid resistance.

However, this method also has some inherent disadvantages associated with it:

- The compaction of any bituminous mixture at the step-off may not be complete due to the bridging of the compacting equipment and could lead to a slight depression at the joint as a result of further consolidation by traffic.

- Reflection cracking will occur directly over the transverse joints of the underlying portland cement concrete pavement and will require periodic maintenance thereafter.

- Of necessity, the overlay will also have to be placed on the passing lane which is in good condition and does not require rehabilitation.

Slabjack

Jacking of whole slabs or portions of slabs has been successfully accomplished in similar situations throughout the country. This method is quite flexible in that it can be adjusted to treat the condition at each individual joint.

However, the procedure is very expensive and requires considerable experience to achieve satisfactory results. Experience has also shown that

many contractors do not possess the necessary expertise and difficulties have been encountered in many instances. To alleviate these problems, some agencies have chosen to develop the required skills within their own maintenance forces and this approach has generally proven more successful.

Mill

Another alternative to the elimination of the step-offs is by the use of machines recently developed to reprofile pavements by rotary drum milling. The advantage of this method is that it can be used selectively only on those joints that require it. However, this method would also require considerable judgment on the amount and extent of milling that is necessary for each joint. Otherwise, another bump can be created beyond the joint if milling does not extend far enough back on the approach slab to make a smooth transition.

Also, this procedure may result in some spalling at the joints. In this event, repairs may be necessary before any resealing is done.

Alleviation of Deterioration

Reseal Joints

Replacement with new joint filler material will lessen the infiltration of water and incompressible materials.

It should be noted, however, that recutting of the joints may be necessary to produce the correct shape for resealing.

Pavement Edgedrains

Edgedrains are utilized primarily to drain free water from a pavement section that has entered through joints and cracks. They are placed beneath the shoulder immediately adjacent to the pavement with the filter material carried up through the subbase course to the bottom of the shoulder. The depth from finished grade to pipe invert (where a pipe is utilized) is usually 30 inches. Proper outletting of water must be provided. This installation is detailed in Chapter 9 of the Highway Design Manual.

The extent of use should be based on a field inspection made during design.

VI. RECOMMENDATIONS

There are two basic strategies involved in rehabilitating I-84. These are restoration of rideability and the alleviation of progressive deterioration. The Task Force recommends that under no circumstances should the restoration steps be taken without including the alleviation steps. This is required to lengthen the service life of the rehabilitated pavement.

Conversely, there are sections of pavement where using the alleviation steps alone would postpone the necessity for restoration long enough to make the work economically feasible. Some scheme will have to be developed to determine where each strategy need be applied. The first step could be to group each section of pavement into one of four categories, such as:

Category 1 - Pavement in worst condition - in immediate need of restoration;

Category 2 - Pavement in need of restoration, not as urgent as in Category 1;

Category 3 - Pavement has deteriorated, will need restoring in approximately five years;

Category 4 - Pavement in relatively good condition.

The initial categorization should be based on pavement condition using measurements such as faulting magnitude and severity of cracking. Observations of joint condition and evidence of pumping would also be included. This compilation would serve to identify the relative need for corrective work on each section in relation to the entire length of pavement. These limits for the type of corrective work and its timing would have to be established using numerous other factors.

These factors include the condition of other roads in the county or region, the importance of the road under consideration, the traffic loading, and the monies available for rehabilitation work. Since the values and inter-relationships of these items will vary from one area to another, it is beyond the scope of this report to make specific recommendations on setting priorities.

However, guidelines can be suggested to establish the categories and outline the work. The limits of each category, as mentioned, will depend on resources available and local interpretations of pavement rideability levels. Therefore, Category 1 should include all pavement sections that can be rehabilitated in the immediate future. Both restoration and alleviation steps would be taken. Category 2 would contain those roads for which funding would be available in about 3 to 5 years. Nothing would be done immediately and then both restoration and alleviation steps would be taken.

Category 3 would consist of those roads that may need work in 4 to 6 years, when the Category 2 roads are being restored. These sections should be considered for alleviation steps to prolong its life, maintaining adequate rideability until restoration funds are available. Finally, there is Category 4, sections with little, if any, deterioration. Nothing would be done to them until they reached the limits of Category 3 when they would be programmed for alleviation work.

This scheme would provide for correcting the worst sections first while slowing the deterioration in other sections. This approach would provide the best return for the required investment.

It is recommended that the pavement not be overlaid. The primary distress mode on I-84 is faulting of the travel lane slabs, the slabs themselves being in good condition. The left lane slabs are also in good condition and are not faulted. The most recent skid data shows that the pavement possesses adequate skid resistance.

Slabjacking by contract is not recommended. This technique must be conducted by people with prior experience and the field operation must be controlled carefully. The New York State Thruway Authority advises that it is improbable that a good slabjacking job can be obtained by contract. Slabjacking by a well trained and properly equipped Regional Maintenance crew(s) should be considered.

Milling of the faulted joints is recommended. While this operation is not trouble free, proper equipment has been developed within the last few years to allow restoration of pavement profile. Satisfactory results can be achieved by experienced personnel. This technique has the advantage of working at the pavement surface. It is recommended that milling first be tried on a small scale.

All transverse joints should be resealed at the time that restoration or alleviation work is done. Several materials are available which will provide at least four years service of adequate sealing.

Edgedrains should be designed into all plans for restoration and alleviation work. The exact locations for placement should be determined during design by the Regional Soils Engineer.

APPENDIX A

LOCATION OF FIELD INVESTIGATIONS

FISH 62-1 ROUTE 9D - ROUTE 9

FISH 62-17 ROUTE 9 - TACONIC STATE PARKWAY

FISH 66-3 TACONIC STATE PARKWAY - LUDDINGTONVILLE ROAD

FISH 66-4 LUDDINGTONVILLE ROAD - ROUTE 311

ROUTE 9

TACONIC STATE PARKWAY

FAU

TES

REG

VIA

LOCATION OF FIELD INVESTIGATIONS

APPENDIX B

PHOTOGRAPHS 1, 2, AND 3

PAVEMENT CONDITIONS

PHOTO 1

TYPICAL FAULTING PROBLEM ON INTERSTATE 84.
PHOTO TAKEN ON CONTRACT FISH 62-1

PHOTO 2

"BLOWHOLE" DEVELOPED AT PAVEMENT-SHOULDER
INTERFACE APPROXIMATELY TWO FEET BEYOND
JOINT IN DIRECTION OF TRAVEL

PHOTO 3

RIDGE OF MATERIAL FOUND BENEATH JOINT AFTER REMOVAL OF PAVEMENT SECTION. WATER PRESENT IN PHOTO FROM SAWING OF PAVEMENT.

APPENDIX C

PAVEMENT SAMPLES

AT "GOOD" AND "POOR"

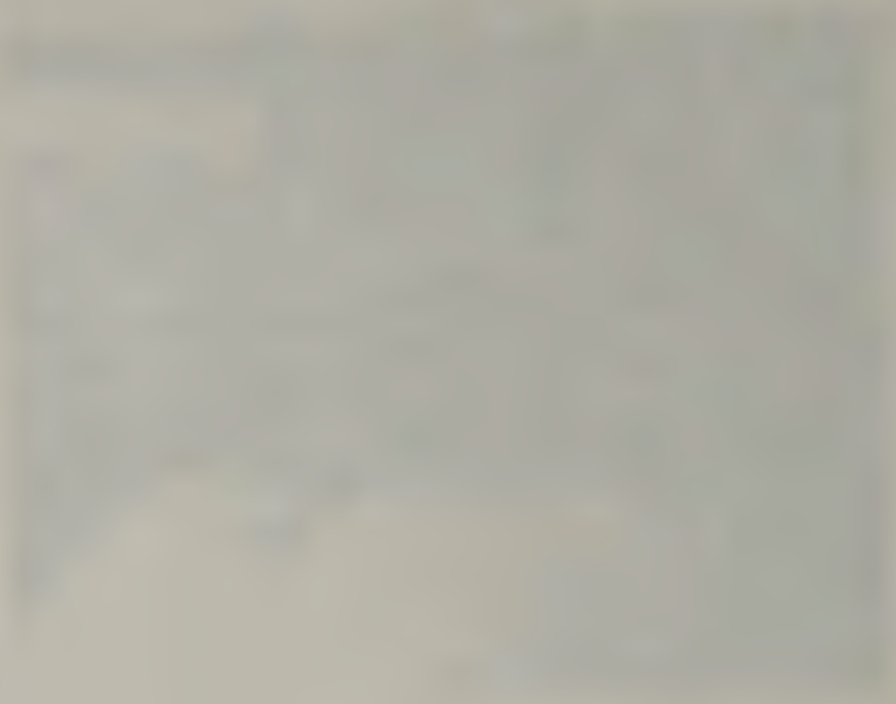
TRANSVERSE JOINTS

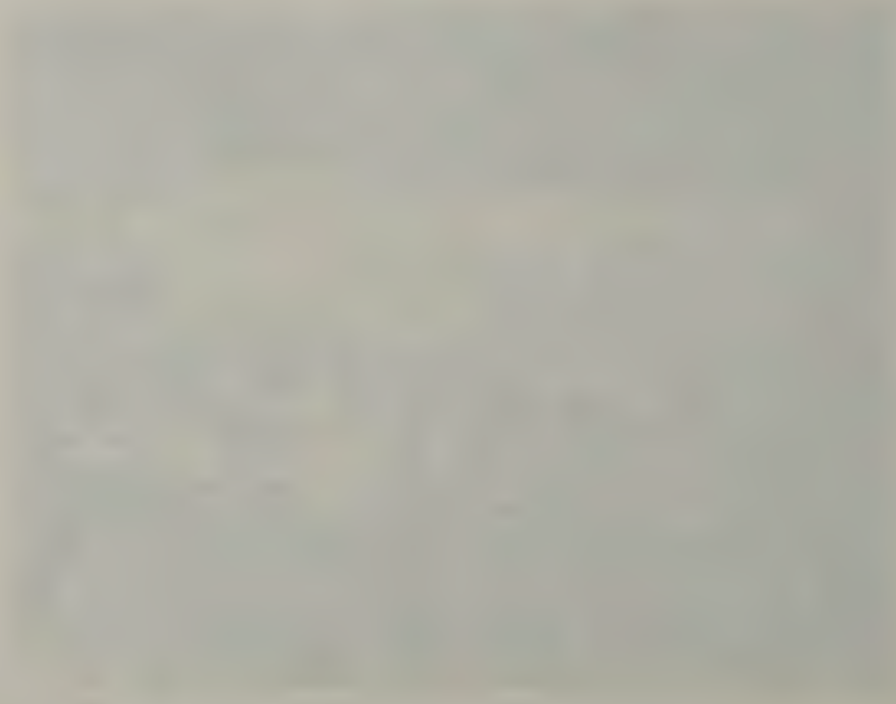
FISH 64-9 84I-83011044 E.B.

GOOD JOINT

Approach Slab

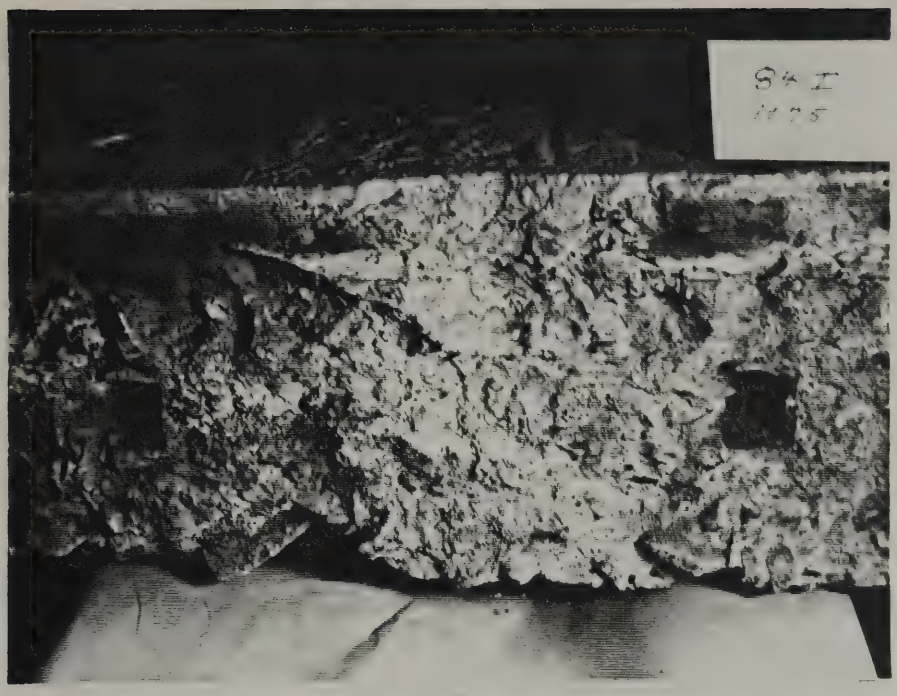
Leave Slab



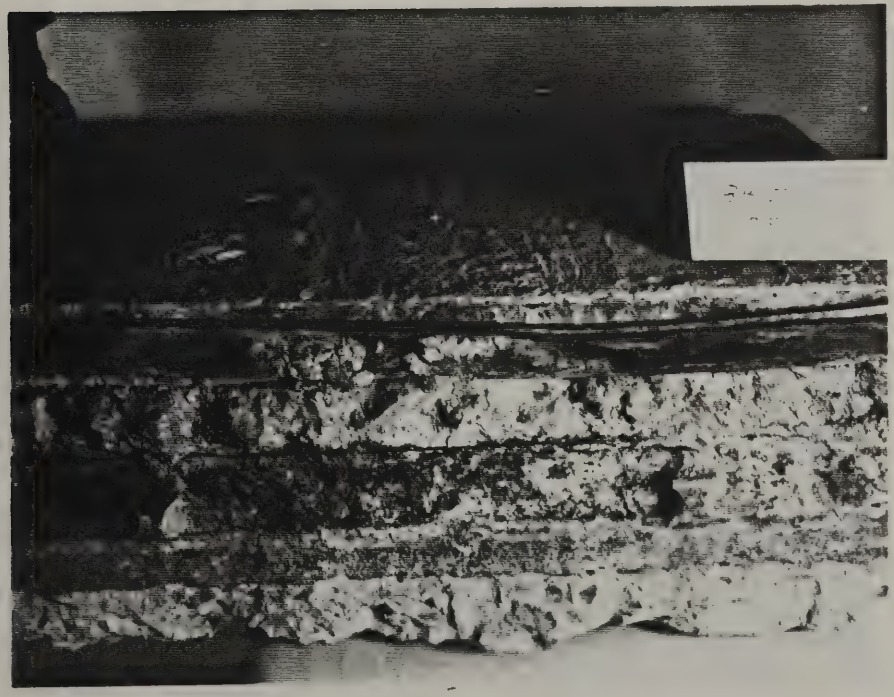


FISH 66-8 84I-83011175 W.B.

GOOD JOINT



Approach Slab



Leave Slab

FISH 62-1 84I-82021017 W.B.

GOOD JOINT

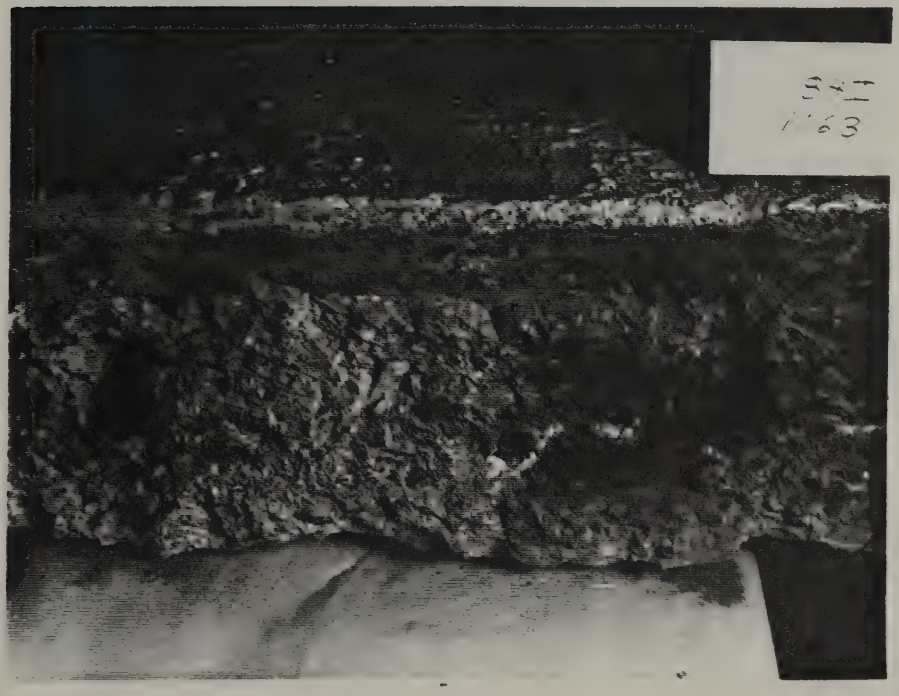
Approach Slab

Leave Slab

FISH 66-8 84I-83011163 E.B.

POOR JOINT

Approach Slab



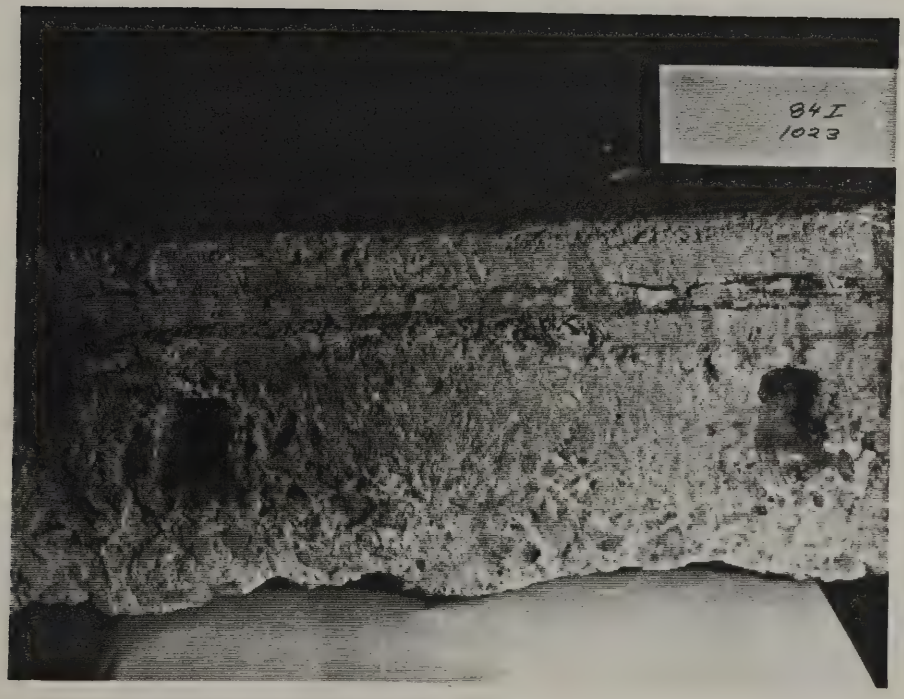
Leave Slab

NOTE: Top portion of female section is missing, also elongation of hole.

FISH 62-1 84I-82021023 E.B.

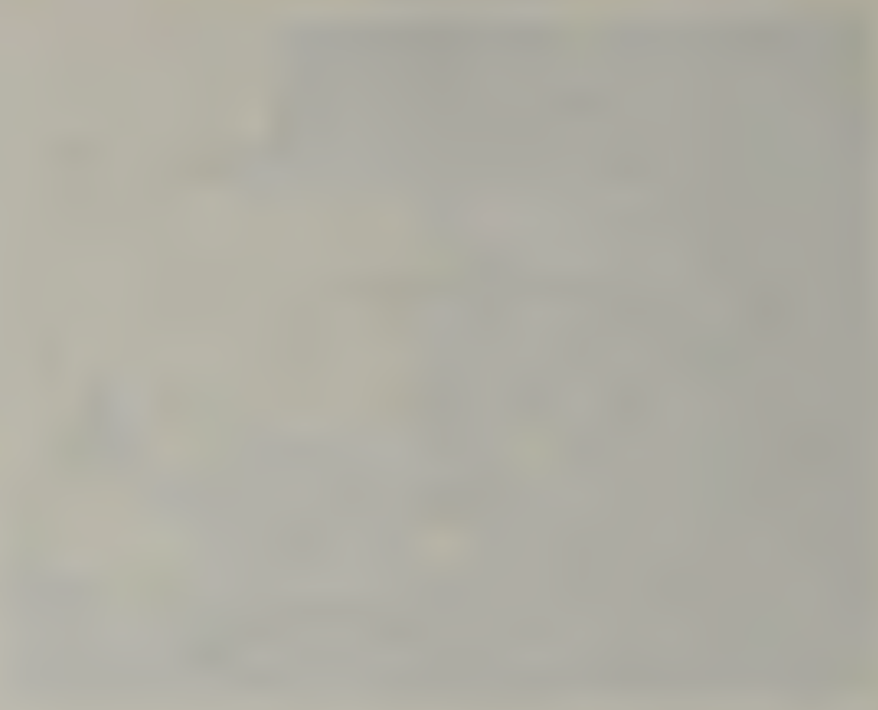
POOR JOINT

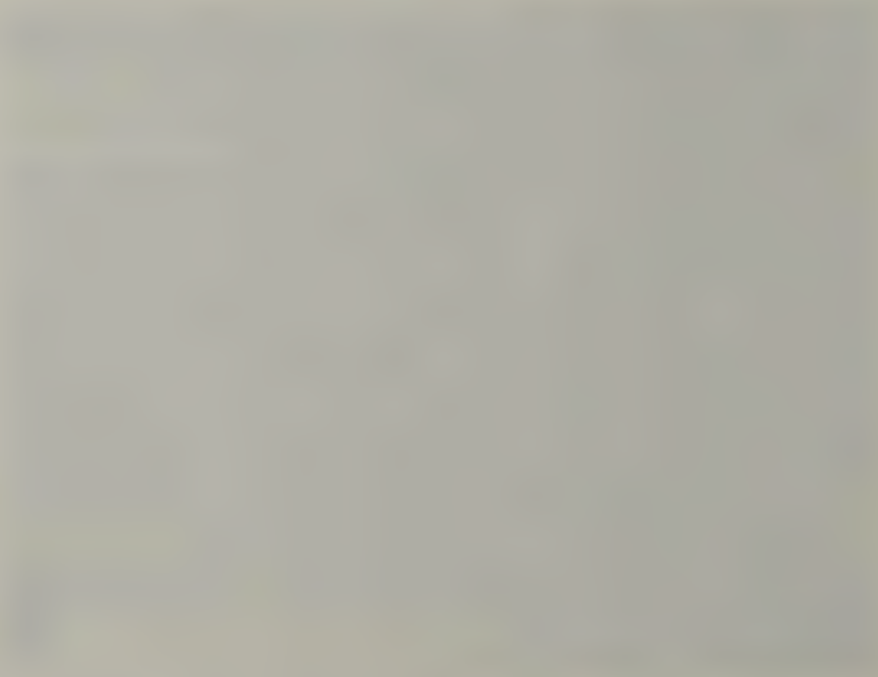
Approach Slab



Leave Slab

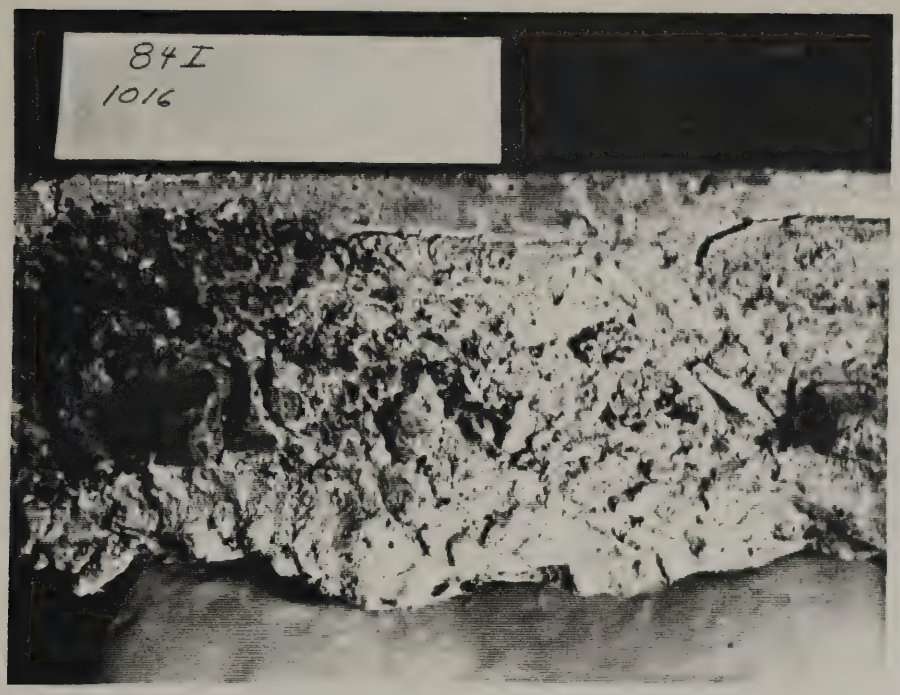
NOTE: Top portion of female section is missing, also elongation of hole.



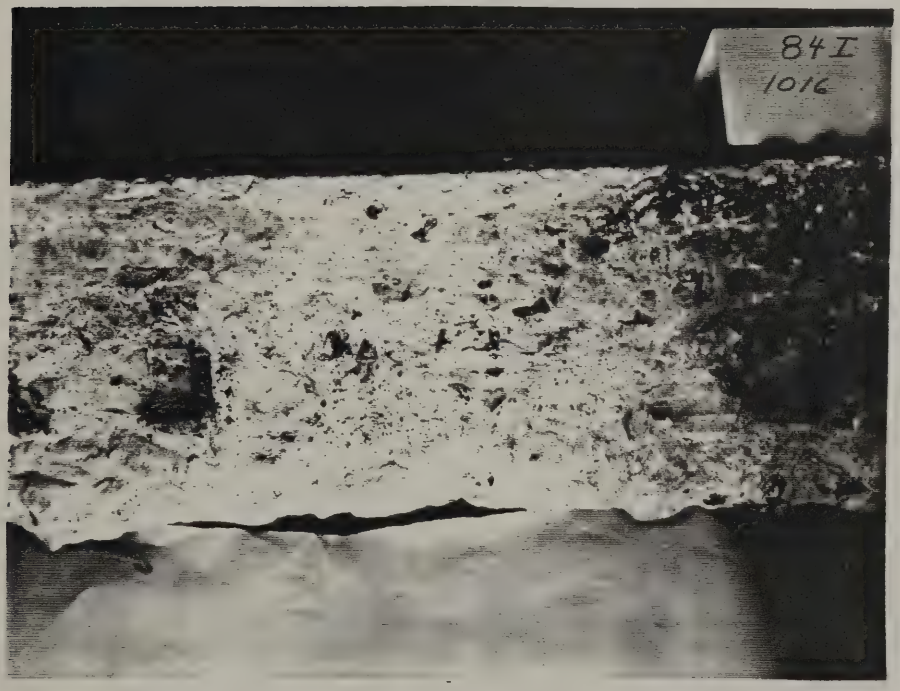


FISH 64-9 84I-83011016 E.B.

POOR JOINT



Approach Slab



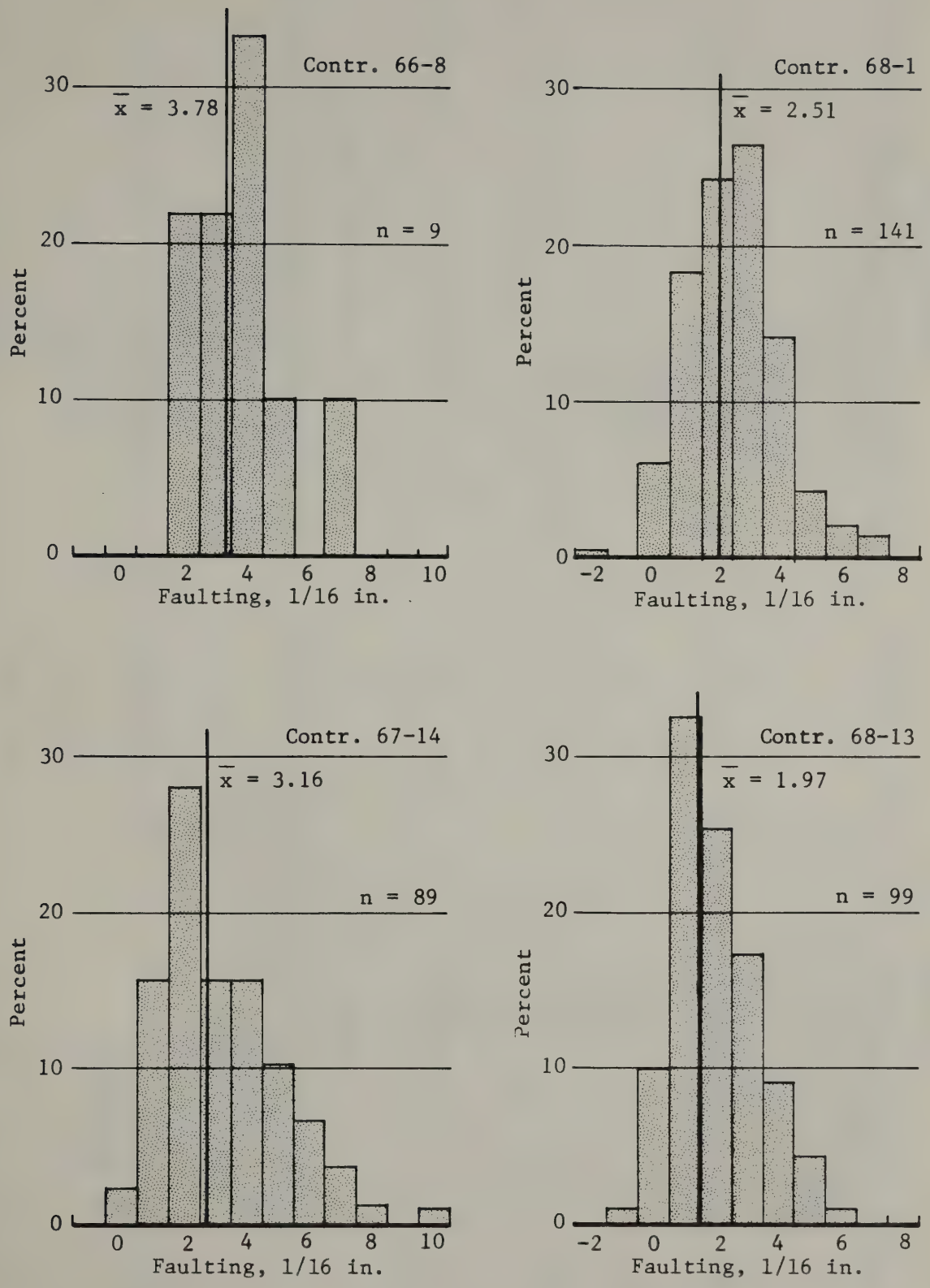
Leave Slab

NOTE: Top portion of female section is missing.

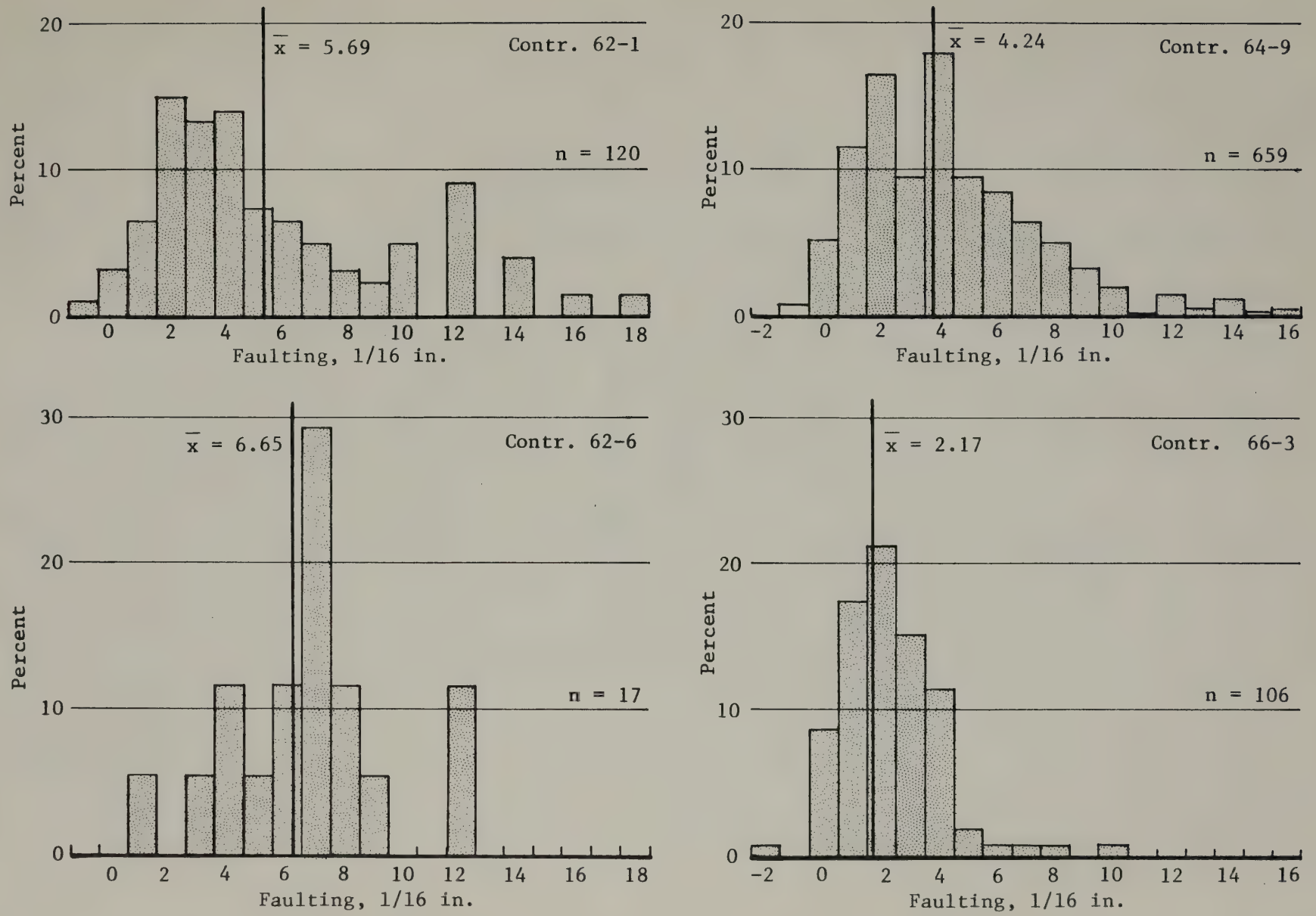
APPENDIX D

FAULTING MEASUREMENTS

AT TEST SITES



FAULTING MEASUREMENTS AT EACH TEST SITE - I-84

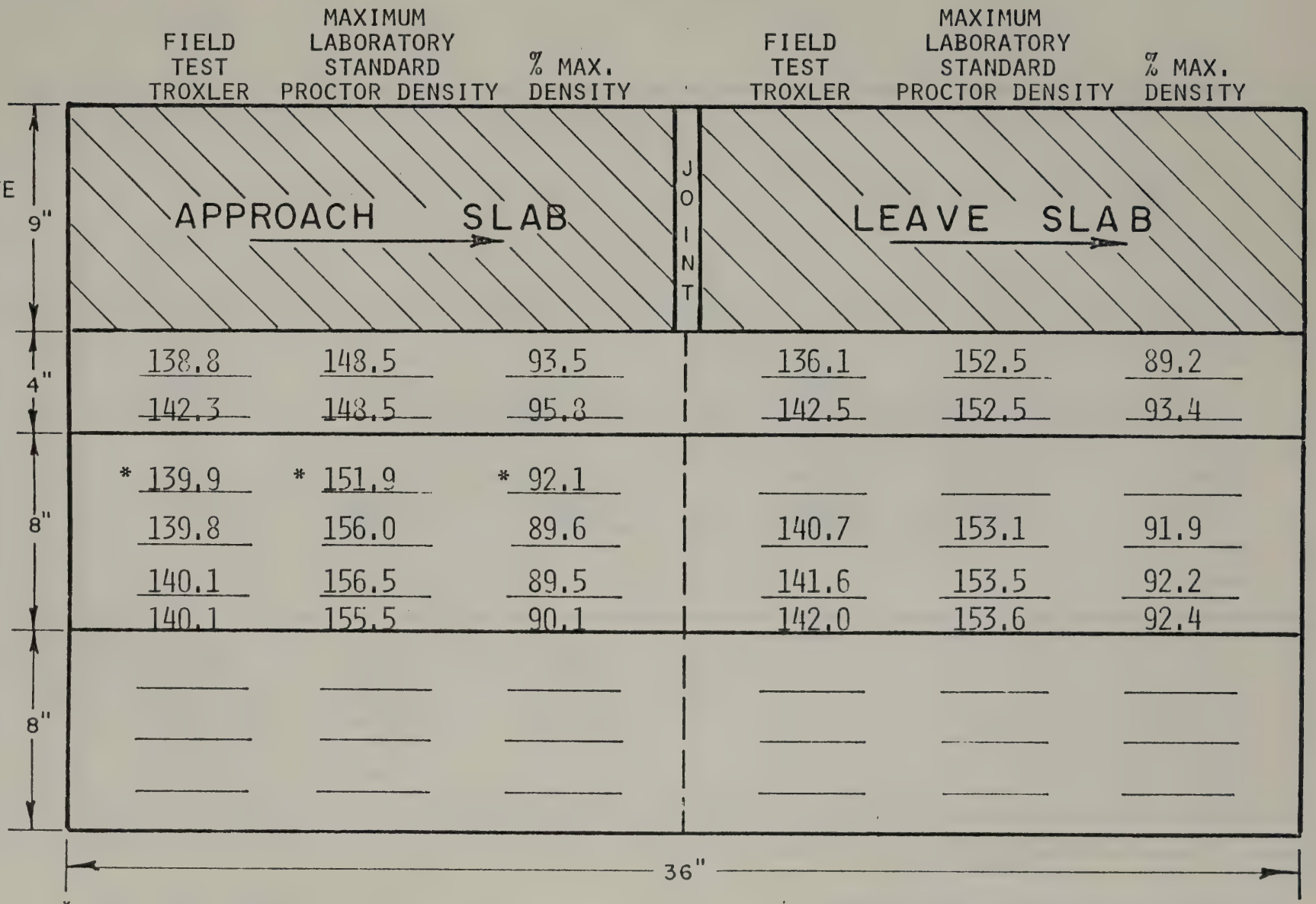


FAULTING MEASUREMENTS AT EACH TEST SITE - I-84

APPENDIX E

SOIL TEST RESULTS

I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT
DENSITY TEST DATA

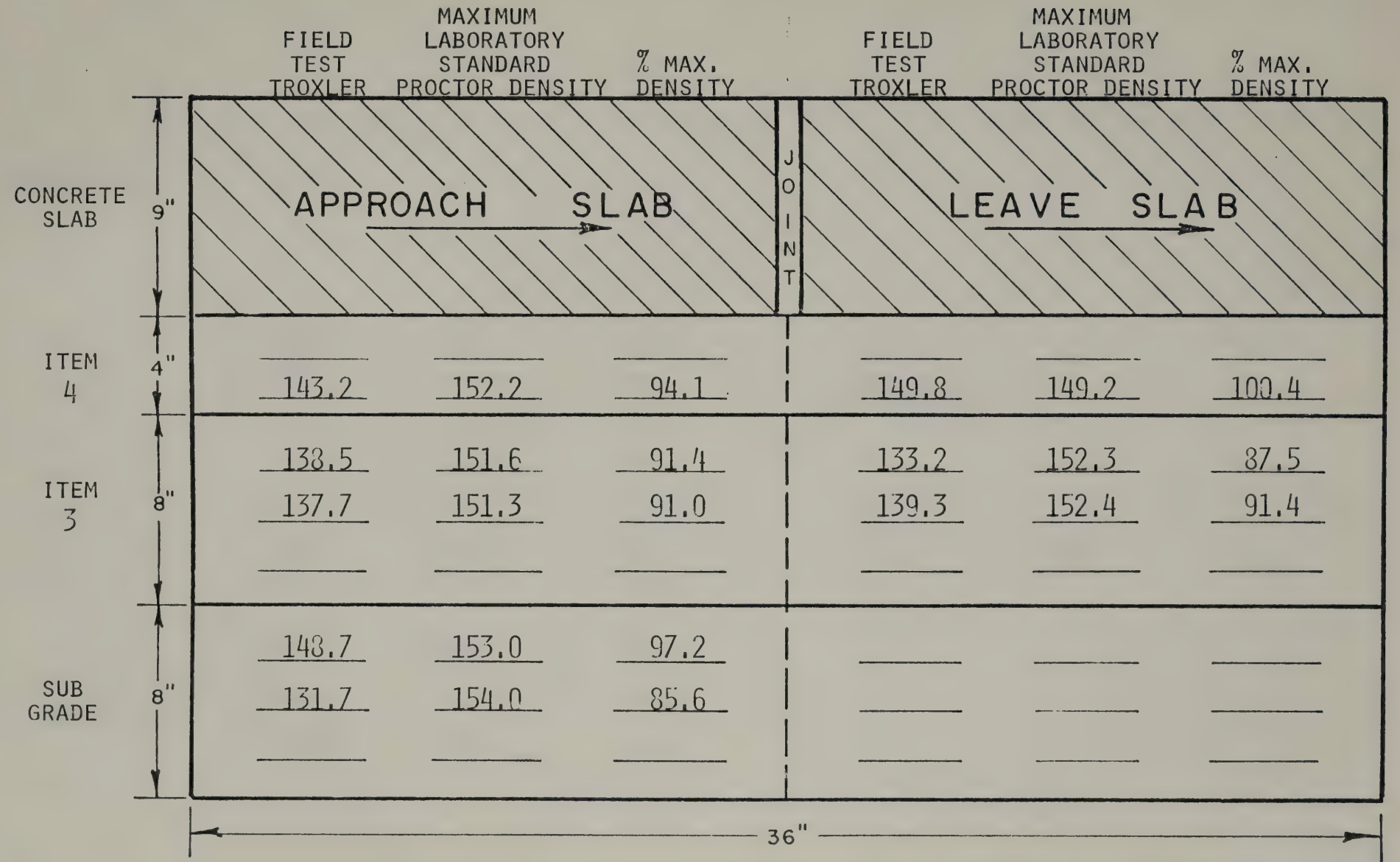


* SAND CONE RESULTS

REFERENCE MARKER 1044 EASTBOUND

ALL VALUES ARE TOTAL WET DENSITIES

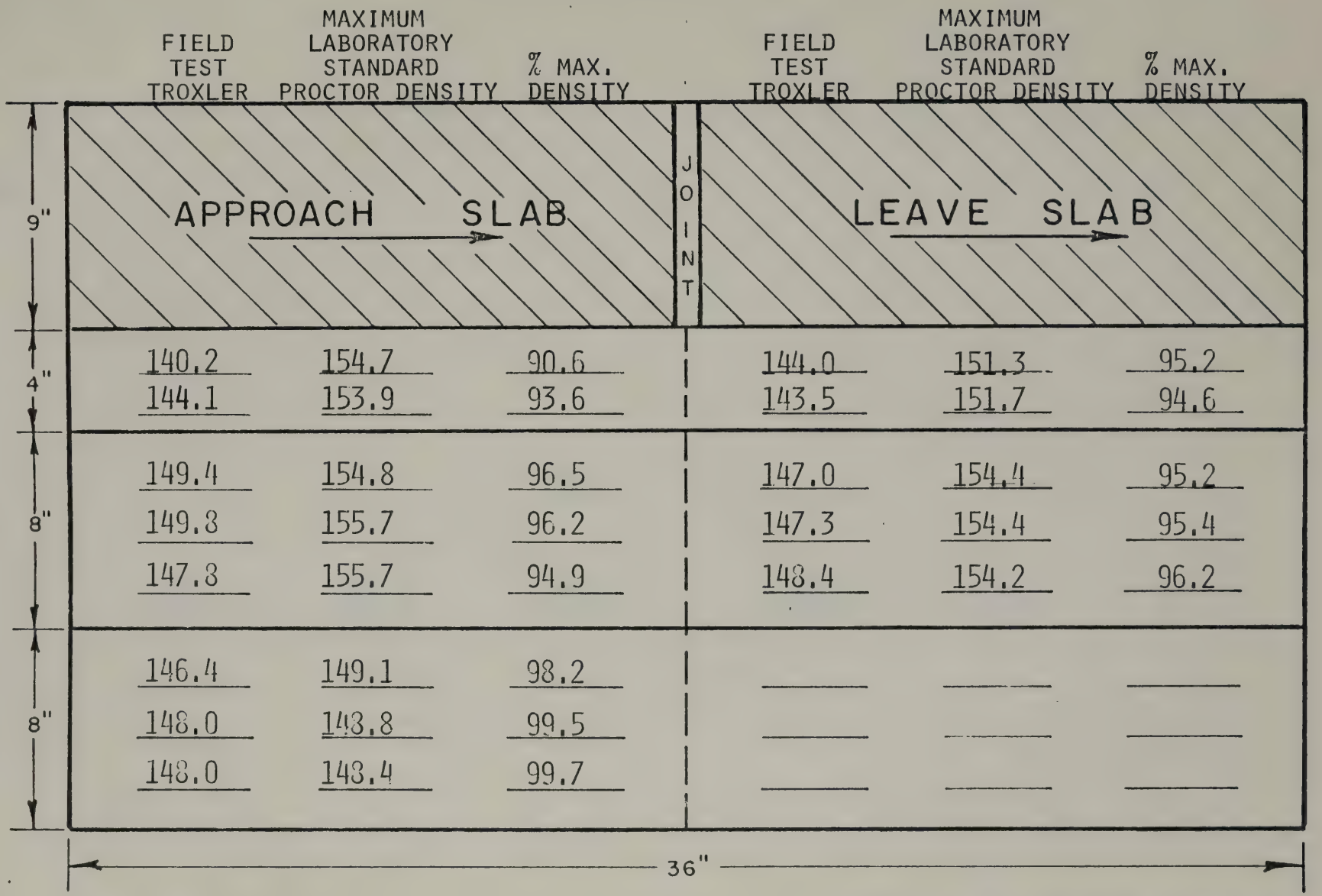
I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT
DENSITY TEST DATA



REFERENCE MARKER 1175 WESTBOUND

ALL VALUES ARE TOTAL WET DENSITIES

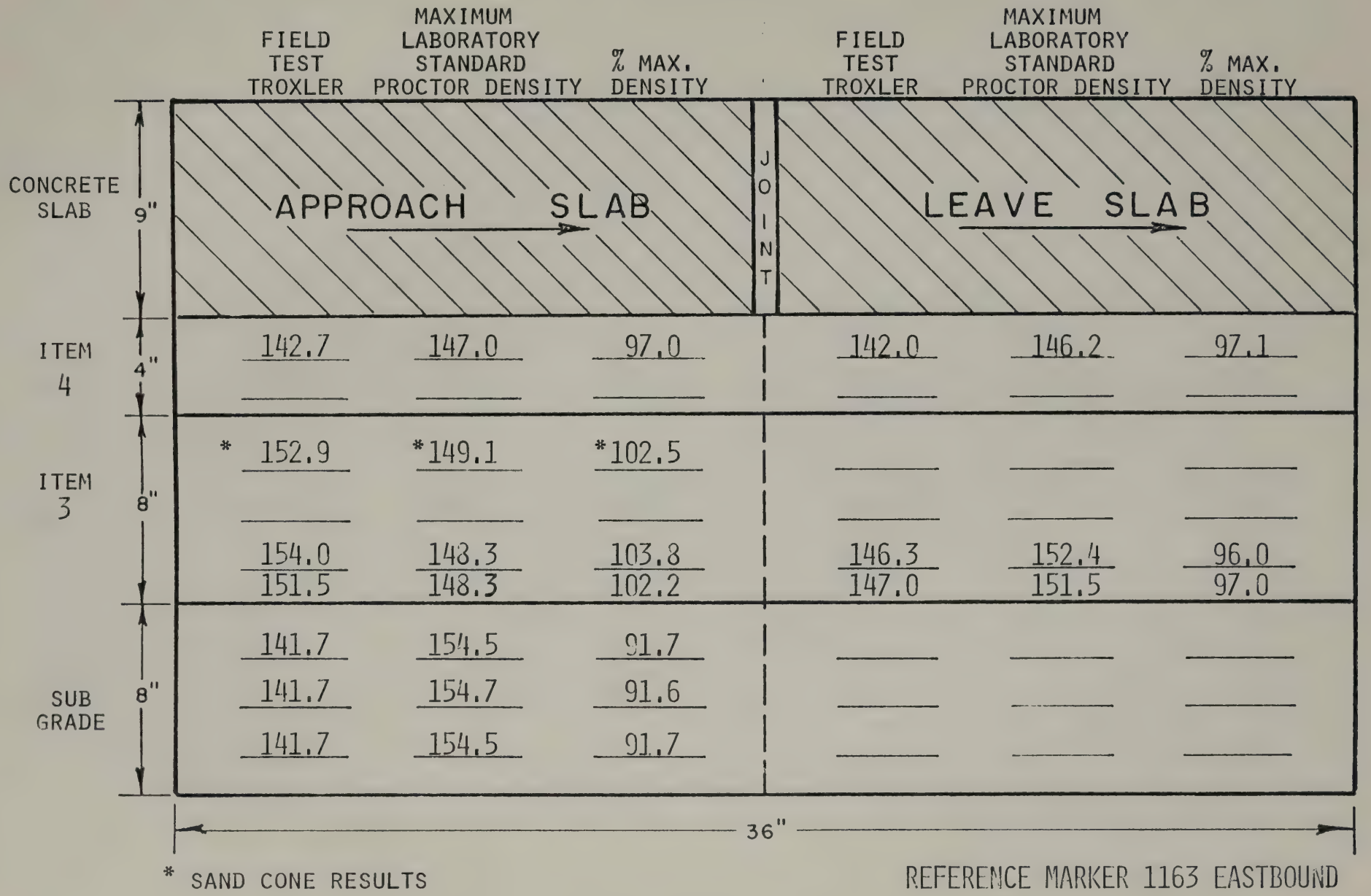
I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT
DENSITY TEST DATA



REFERENCE MARKER 1017 WESTBOUND

ALL VALUES ARE TOTAL WET DENSITIES

I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT
DENSITY TEST DATA

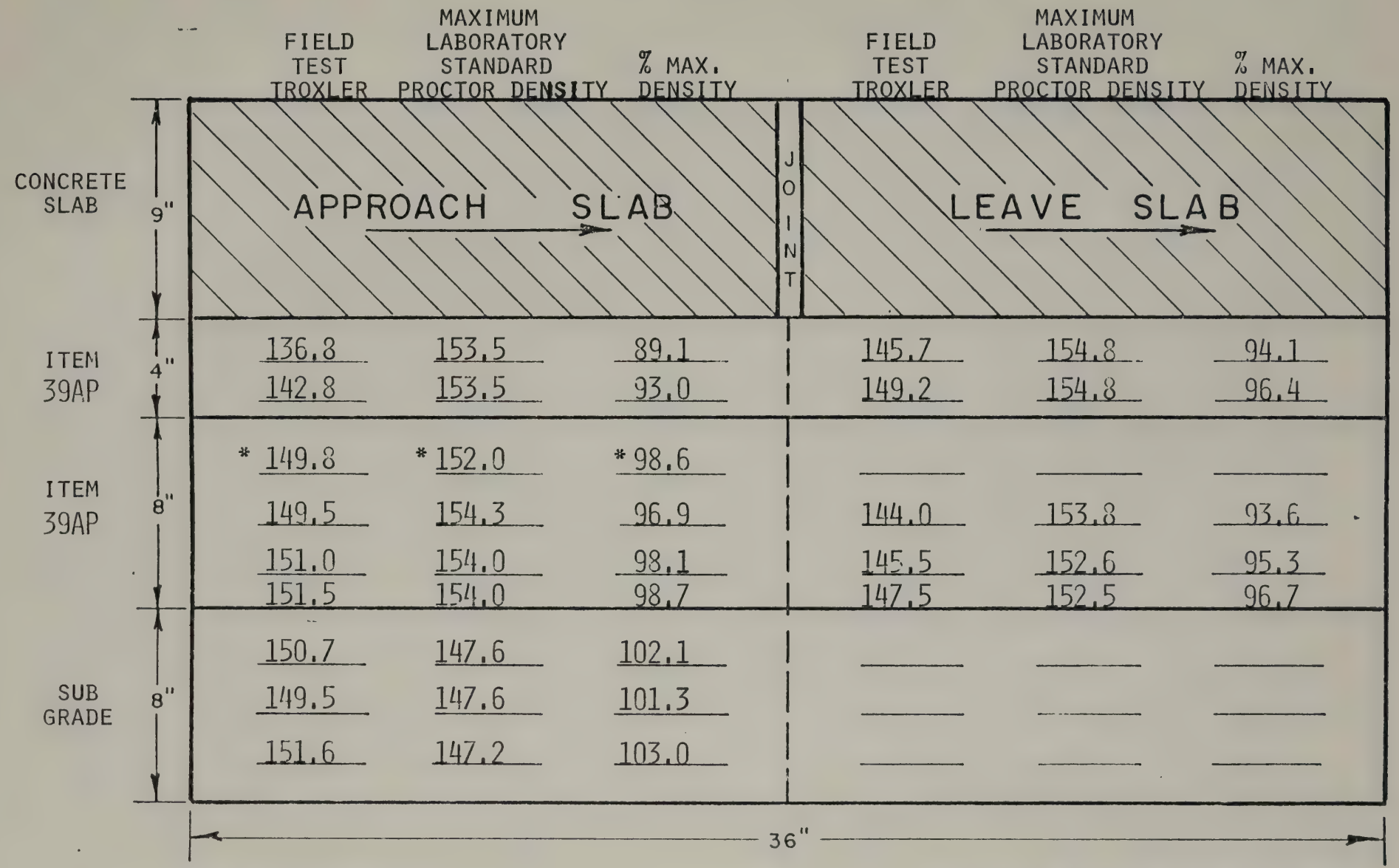


* SAND CONE RESULTS

REFERENCE MARKER 1163 EASTBOUND

ALL VALUES ARE TOTAL WET DENSITIES

I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT
DENSITY TEST DATA

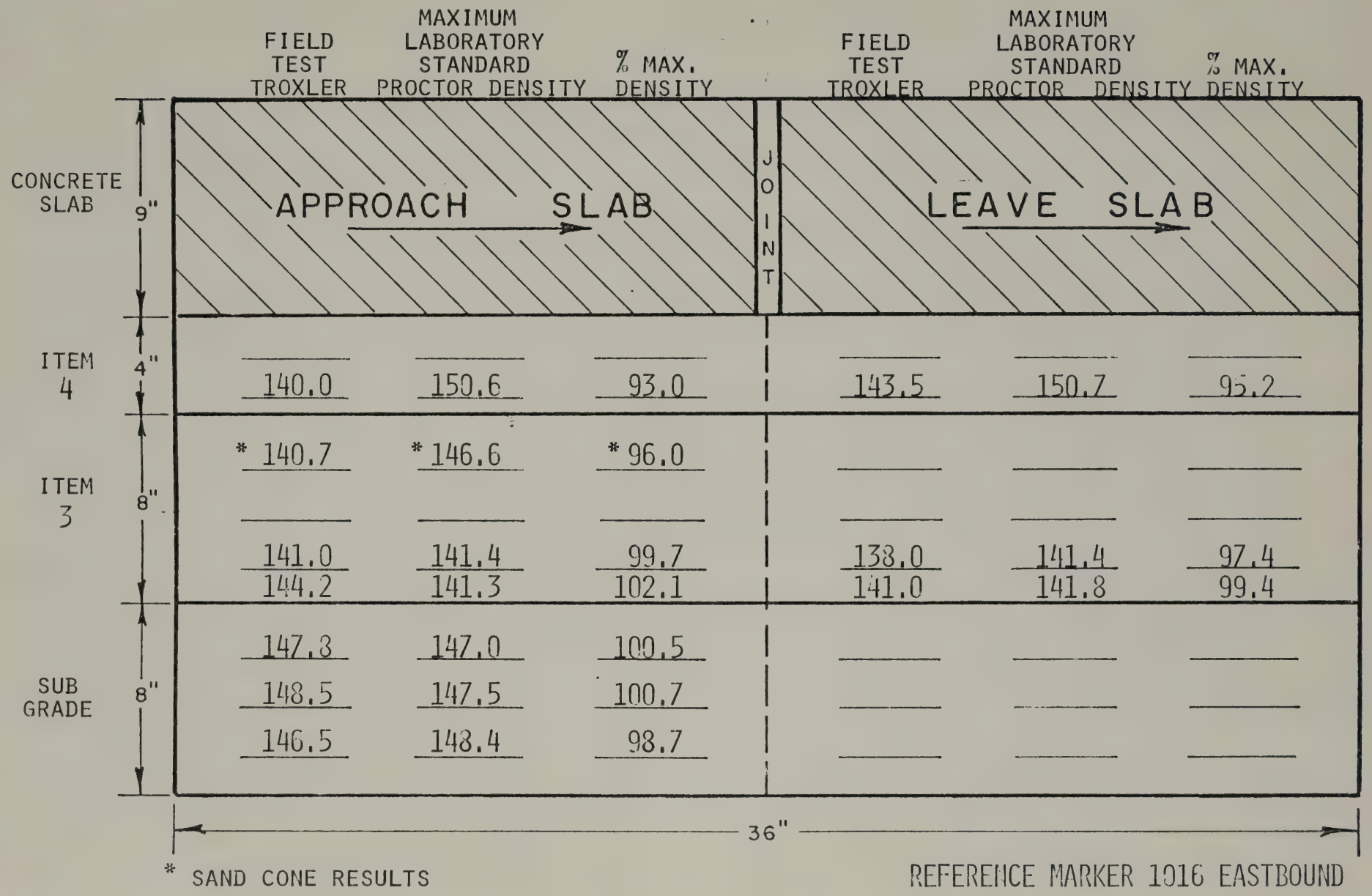


*SAND CONE RESULTS

REFERENCE MARKER 1023 EASTBOUND

ALL VALUES ARE TOTAL WET DENSITIES

I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT
DENSITY TEST DATA



ALL VALUES ARE TOTAL WET DENSITIES

STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION SOIL MECHANICS BUREAU

SHEET No. 1 OF 2
DATE JUNE & JULY 1977

SUMMARY OF LABORATORY TEST RESULTS

PROJECT I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT REGION 8 COUNTY ORANGE & DUTCHESS PIN No 8061.41-111

LABORATORY No.	TRAFFIC DIRECTION	REFERENCE MARKER	CONTRACT ITEM	RELATION TO JOINT	TYPE OF SAMPLE	MAGNESIUM SULFATE CORR. % LOSS	OPT. MOISTURE-%	MAX. DRY DENSITY LBS. PER CU. FT.	SP. GR. + 3/4"	SP. GR. - 3/4"	LIMIT TESTS LIQUID LIMIT-%	LIMIT TESTS PLASTIC INDEX	SIEVE ANALYSIS MECHANICAL ANALYSIS PERCENT FINER THAN 4"	3"	2"	1"	3/4"	1 1/2"	1/4"	No. 4	No. 10	No. 20	No. 40	No. 60	No. 100	No. 200	HYD. ANAL. .02MM	.002MM	
8-56SP-1	W.B.	1017	39AP	EAST	BAG	4.0	8.3	133.5	2.66			N.P.		100.0	96.0	81.0	73.7	67.3	56.8	53.2	43.1	28.4	17.3	11.4	8.7	7.1			
-2	W.B.	1017	39AP	WEST	BAG	2.3	8.5	133.0	2.68			N.P.		100.0	98.4	86.6	81.7	75.1	63.2	58.2	48.0	31.6	19.5	13.1	10.0	8.1			
-3	W.B.	1017	39AP	WEST	BAG	2.0	9.0	133.2	2.65			N.P.		100.0	95.6	81.1	76.3	70.0	58.5	54.8	42.5	26.0	15.0	10.4	8.5	7.3			
-4	W.B.	1017	39AP	EAST	BAG	2.4	7.8	136.8	2.63			N.P.		100.0	97.0	85.6	78.9	72.5	60.0	55.2	42.8	26.9	15.6	10.8	9.0	7.7			
-5	W.B.	1017	SUB	MIDDLE	BAG	-	10.8	123.7	2.70	2.72	19.5	3.8	80.0	80.0	68.9	60.2	59.1	58.6	54.8	53.9	51.7	49.6	48.2	47.2	46.1	42.5	18.4	5.8	
-6	E.B.	1023	39AP	WEST	BAG	1.5	6.7	137.2	2.70			N.P.		100.0	98.1	86.1	79.3	73.1	63.0	58.9	49.6	33.2	21.0	14.4	11.4	9.4			
-7	E.B.	1023	39AP	EAST	BAG	1.2	7.0	137.5	2.68			N.P.		100.0	91.5	80.9	75.4	69.5	60.3	55.9	47.4	34.2	24.2	17.8	14.1	11.2			
-8	E.B.	1023	39AP	WEST	BAG	2.1	7.6	135.1	2.67			N.P.		100.0	93.3	81.6	74.4	68.6	56.4	49.8	36.2	21.1	12.6	8.9	7.2	6.2			
-9	E.B.	1023	SUB	MIDDLE	BAG	-	8.9	132.2	2.71	2.70	19.4	5.5			100.0	98.8	98.0	96.8	94.6	91.7	85.0	76.8	70.2	64.0	58.8	52.7	36.4	16.2	
-10	E.B.	1044	4	EAST	BAG	3.3	7.2	136.9	2.60			N.P.			100.0	86.6	79.1	71.7	59.9	58.2	52.6	40.6	28.3	18.7	13.5	10.5			
-11	E.B.	1044	4	WEST	BAG	6.7	7.0	133.7	2.58			N.P.			100.0	89.6	84.5	74.7	62.3	59.2	50.3	38.3	26.4	17.1	12.3	9.3			
-12	E.B.	1044	3	WEST	BAG	4.1	7.5	135.0	2.55			N.P.		100.0	89.0	71.0	65.4	60.2	50.7	48.0	38.5	26.0	17.2	12.1	9.6	7.9			
-13	W.B.	1175	4	WEST	BAG	5.6	7.5	135.2	2.61			N.P.			100.0	94.1	88.7	82.0	70.4	66.0	57.2	40.1	27.5	19.6	14.8	11.7			
-14	W.B.	1175	4	EAST	BAG	10.9	8.0	135.0	2.64			N.P.		100.0	97.4	91.9	86.5	79.3	68.5	64.2	54.4	38.7	25.6	17.2	12.2	9.1			
-15	W.B.	1175	3	EAST & WEST	BAG	21.1	8.5	134.1	2.65			N.P.			100.0	97.7	94.2	88.7	74.1	69.9	57.2	39.6	25.6	15.4	9.5	6.7			
-16	W.B.	1175	SUB	MIDDLE	BAG	-	8.0	134.8	2.70	2.69	20.1	6.2			100.0	86.4	82.3	76.9	67.0	62.4	52.2	42.0	36.5	32.7	29.5	26.3	16.9	7.3	
-17	E.B.	1016	4	WEST	BAG	3.8	7.8	135.1	2.59			N.P.			100.0	87.8	81.0	70.9	59.5	54.4	45.9	36.1	27.0	19.2	13.8	10.4			
-18	E.B.	1016	4	EAST	BAG	3.7	7.3	136.3	2.58			N.P.			100.0	82.6	75.4	67.6	56.7	53.1	44.8	35.9	27.2	19.4	14.4	10.9			
-19	E.B.	1016	3	EAST	BAG	4.3	8.2	134.6	2.62			N.P.		100.0	97.4	90.8	87.5	81.8	71.5	67.7	60.6	50.1	39.2	28.1	19.2	12.4			
-20	E.B.	1016	SUB	MIDDLE	BAG	-	7.5	135.5	2.62	2.66	13.1	0.9	100.0	93.1	89.5	84.8	82.4	78.3	71.4	69.6	64.8	58.5	52.1	45.1	37.9	29.9	15.7	4.7	
-21	E.B.	1163	4	WEST	BAG	7.6	7.3	138.9	2.62			N.P.			100.0	93.5	87.3	80.6	68.7	65.1	55.6	38.6	27.1	20.3	15.6	12.1			
-22	E.B.	1163	4	EAST	BAG	6.0	7.9	135.9	2.62			N.P.			100.0	91.9	88.6	79.5	67.9	63.4	49.2	30.7	20.4	15.5	12.8	10.7			
-23	E.B.	1163	3	EAST	BAG	13.6	7.9	136.7	2.61			N.P.		100.0	98.0	82.6	76.7	70.0	58.1	54.5	45.5	30.3	20.4	15.5	12.6	10.4			
-24	E.B.	1163	SUB	MIDDLE	BAG	-	9.5	129.0	2.50	2.66	N.P.	N.P.	100.0	78.1	78.1	75.1	73.2	70.7	65.2	62.7	56.4	43.4	31.9	22.6	17.0	13.9	8.4	3.6	

STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION SOIL MECHANICS BUREAU

SUMMARY OF LABORATORY TEST RESULTS

DATE June & July 197

REGION 8 COUNTY Orange & Dutchess

PROJECT I-84, PORTLAND CEMENT CONCRETE PERFORMANCE REPORT PIN No. 8061.41-111

LABORATORY No.	TRAFFIC DIRECTION	REFERENCE MARKER	TYPE OF SAMPLE	SAMPLE LOCATION	FIELD MOISTURE CONTENT %	SIEVE ANALYSIS / MECHANICAL ANALYSIS / PERCENT FINER THAN												
						2"	1"	3/4"	1/2"	1/4"	No. 4	No 10	No. 20	No. 40	No. 60	No. 100	No. 200	
8-56SP-25	W.B.	1017	JAR	Ridge Material				100.0	95.2	88.9	86.9	78.8	61.6	45.3	29.9	18.5	11.3	
-26	W.B.	1017	JAR	Surface Mat'l - West				100.0	94.9	77.4	66.6	44.3	31.4	23.2	17.0	12.8	9.7	
-27	W.B.	1017	JAR	Surface Mat'l - East			100.0	93.3	88.1	76.7	70.9	52.8	34.3	21.7	12.9	7.7	5.5	
-28	W.B.	1017	JAR	Item 39AP Proctor (M.C.)	7.9													
-29	W.B.	1017	JAR	Subgrade Proctor (M.C.)	19.3													
-30	E.B.	1044	JAR	Ridge Material					100.0	97.0	95.0	86.8	73.2	57.3	39.8	28.9	20.2	
-31	E.B.	1044	JAR	Surface Mat'l - East				100.0	99.2	88.8	83.4	72.2	55.6	36.5	18.6	10.0	6.1	
-32	E.B.	1044	JAR	Surface Mat'l - West				100.0	97.0	89.3	85.9	76.6	65.2	46.4	23.8	12.8	8.1	
-33	E.B.	1044	JAR	Item 3 Proctor (M.C.)	5.9													
-34	E.B.	1023	JAR	Ridge Material		100.0	95.8	90.9	85.2	77.2	75.6	70.1	59.0	42.9	31.4	24.2	15.1	
-35	E.B.	1023	JAR	Surface Mat'l - West				100.0	96.3	90.7	87.5	75.8	61.9	51.3	42.8	35.7	26.8	
-36	E.B.	1023	JAR	Surface Mat'l - East			100.0	92.1	82.4	75.2	74.3	72.3	67.4	63.8	61.4	58.7	52.0	
-37	E.B.	1023	JAR	Item 39AP (M.C.)	6.4													
-38	E.B.	1023	JAR	Subgrade Proctor (M.C.)	9.6													
-39	E.B.	1016	JAR	Ridge Material			100.0	91.5	71.4	54.6	47.8	39.1	33.8	25.6	15.0	8.1	5.2	
-40	E.B.	1016	JAR	Surface Mat'l - East		100.0	67.6	58.7	45.8	36.1	34.7	33.0	31.4	27.0	17.6	8.4	3.2	
-41	E.B.	1163	JAR	Ridge Material			100.0	97.6	90.9	82.9	80.6	75.6	61.4	45.6	31.8	22.7	15.4	
-42	W.B.	1175	JAR	Ridge Material				100.0	92.6	83.9	80.0	70.9	54.9	36.6	23.6	16.2	10.2	
-43	W.B.	1175	JAR	Item 3 (M.C.)	8.6													

LABORATORY NO.	TEST SECTION DESIGNATION	RECORD BOOK NUMBER	TYPE OF SAMPLE	SAMPLE
-25	W.B.	1017	JAR	
-26	W.B.	1017	JAR	
-27	W.B.	1017	JAR	
-28	W.B.	1017	JAR	
-29	W.B.	1017	JAR	
-30	E.B.	1044	JAR	
-31	E.B.	1044	JAR	
-32	E.B.	1044	JAR	
-33	E.B.	1044	JAR	
-34	E.B.	1023	JAR	
-35	E.B.	1023	JAR	
-36	E.B.	1023	JAR	
-37	E.B.	1023	JAR	
-38	E.B.	1023	JAR	
-39	E.B.	1016	JAR	
-40	E.B.	1016	JAR	
-41	E.B.	1163	JAR	
-42	W.B.	1175	JAR	
-43	W.B.	1175	JAR	

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